Appl. No. 09/851,940 Amdt. dated October 21, 2003 Reply to Office Action of July 21, 2003

## Amendments to the Claims:

Claims 1-24 have been amended. New claims 25-30 have been added. This listing of claims will replace all prior versions, and listings of claims in the application:

## Listing of Claims:

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1. (Currently Amended) A method of analyzing intersections between objects in computer animation comprising the steps of: providing a plurality of objects represented by a plurality of meshes, with each of said plurality of objects being represented by one of said plurality of meshes and each of said meshes being formed by a set of vertices, where a set of pairs of vertices of said set of vertices define a set of edges; checking all edges of said meshes to determine if said set of edges of said meshes intersect with any of said plurality of meshes; tracing an intersection path formed by intersection of said edges with any of said plurality of meshes; and determining which vertices of said meshes are contained within said intersection path; and and setting a polarity of each of said contained vertices to indicate that those vertices are contained within said intersection path. setting a polarity of each vertex contained within said intersection path to indicate that said vertex is contained within said intersection path, wherein a polarity of a vertex is set based upon a number of disconnected regions formed by said intersection path.

2. (Currently Amended) [[A]] The method of analyzing intersections between objects according to claim 1 wherein said step of determining which vertices of said meshes are contained within said intersection path comprises examining vertices of a mesh that contains said intersection path within a certain distance from a particular edge of said intersection path and characterizing said vertices to determine which vertices of said meshes are contained within said intersection path.



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3. (Currently Amended) [[A]] <u>The</u> method of analyzing intersections between objects according to claim 1 wherein said-step of determining which vertices of said meshes are contained within said intersection path comprises the steps of:

selecting an arbitrary edge of a mesh that crosses said intersection path, where said arbitrary edge is formed by vertices u and v and where said mesh contains said intersection path;

performing a search of said mesh, radiating from one of said vertices u and v, identifying all vertices in all of said edges that cross said intersection path, and defining the set of vertices identified as a playpen;

tracing said intersection path and identifying vertices, within said playpen, on a left side of said intersection path as left and retracing said intersection path in an opposite direction and identifying vertices, with said playpen, on a right side of said intersection path as right;

determining whether vertices adjacent to vertices identified as left and right lie outside of said playpen:

discarding said intersection path when at least one of both left and right identified vertices lie outside said playpen;

determining whether at least one vertex adjacent to said right identified vertices lies outside said playpen; and

changing said polarity of characterizing each of said left identified vertices to indicate that those vertices are as contained within said intersection path when at least one vertex adjacent to said right identified vertices lies outside said playpen and changing said polarity of characterizing each of said right identified vertices to indicate that those vertices are as contained within said intersection path when at least one vertex adjacent to said left identified vertices lies outside said playpen.

4. (Currently Amended) [[A]] The method of analyzing intersections between objects according to claim 1 wherein said intersection path is a self-intersection with the intersection path being contained in a single mesh and wherein said step-of setting a polarity of



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each <u>vertex</u> of said contained vertices to indicate that those vertices are contained within said

intersection path comprises; setting the

associating a first color of said vertices that are with each vertex that is contained within said intersection path to a predetermined color when the intersection yields one region; and

when the intersection yields first and second disconnected regions, setting the associating a second color of vertices of a first portion of with each vertex contained in said first disconnected region and associating a third color with each vertex contained in the second disconnected region. said single mesh contained within said intersection path to a first color and setting the color of vertices of a second portion of said single mesh contained within said intersection path to a second color when the intersection yields two unconnected regions.

- 5. (Currently Amended) [[A]] The method of analyzing intersections between a first objects according to claim 1 wherein said intersection path is an intersection between a first mesh and a second mesh and said step of wherein setting a polarity of each vertex of said contained vertices to indicate that those vertices are contained within said intersection path comprises setting the associating a first color [[of]] with vertices of the first mesh contained within said intersection path to a first color and setting the associating a second color [[of]] with vertices of the second mesh contained within said intersection path to a second color [[of]] with vertices of the second mesh contained within said intersection path to a second color.
- 6. (Currently Amended) [[A]] The method of analyzing intersections between objects according to one of claims claim 4 and 5, further comprising displaying said objects on a computer display with vertices colored as said vertices have been set displayed in colors associated with the vertices.
- 7. (Currently Amended) A method of determining pinching between objects in computer animation comprising the steps of:

providing a plurality of objects represented by a plurality of meshes, with each of said plurality of objects being represented by one of said plurality of meshes and each of said meshes being formed by a set of vertices;



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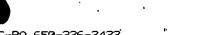
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determining an intersection path formed by analyzing intersections between said		
objects and changing a polarity of each of a plurality vertices contained in an intersection path		
erented by an intersection of said plurality of meshes;		
setting a polarity of each vertex contained within said intersection path based		
upon a number of disconnected regions formed by said intersection path;		
selecting a particular vertex of said set of vertices bound between surfaces of said		
objects and closer to one of said surfaces, where said surfaces have defined insides and outsides		

and said particular vertex is inside of both surfaces;
 determining whether any vertices inside of said surfaces have their polarities set;

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indicating that said particular vertex is pinched when any vertices inside of said surfaces have their polarities set.

- 8. (Currently Amended) [[A]] The method of determining pinching between

  objects in computer animation according to claim 7 further comprising the step of:

  constraining motion of said pinched particular vertex when motion in said

  computer animation is simulated.
  - 9. (Currently Amended) [[A]] The method of determining pinching between objects in computer animation according to claim 7 wherein said step of changing setting a polarity of each vertex of a plurality vertices contained in an intersection path comprises setting the associating a color of each of a plurality vertices with each vertex contained in an the intersection path, the method and further comprising the step of:

    displaying said objects on a computer display with vertices colored as said vertices have been set displayed in colors associated with the vertices such that an animator can see the intersection and pinching of said objects is visually displayed.
  - 10. (Currently Amended) A method of simulating motion of objects in computer animation, the method comprising the steps of:



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3	providing a plurality of objects represented by a plurality of meshes, with each of		
4	said plurality of objects being represented by one of said plurality of meshes and each of said		
5	meshes being formed by a set of vertices, where at least one of said objects is an animated object		
6	and at least one of said objects is a simulated object;		
7	positioning said objects at some time $t$ to provide one frame of said computer		
8	animation;		
9	determining an intersection path formed by analyzing intersections between said		
10	objects-and-setting a polarity of each of a plurality vertices contained in an intersection path		
11	created by an intersection of said plurality of meshes;		
12	setting a polarity of each vertex contained within said intersection path based		
13	upon a number of disconnected regions formed by said intersection path;		
14	setting a simulated force between vertices of said at least one simulated object		
15	based on the polarity set for said vertices of said at least one simulated object; and		
16	advancing the computer animation to a time $t + \Delta t$ and simulating motions of said		
17	objects using said simulated force to simulate motions of said at least one simulated object.		
1	11. (Currently Amended) [[A]] The method of simulating motion of objects in		
2	computer animation according to claim 10 wherein		
3	when said intersection path is a self-intersection with the intersection path		
4	contained in a single mesh, said step of setting a polarity of each vertex contained within said		
5	polarity of each of said plurality vertices contained in said intersection path comprises setting the		
6	associating a first color of with each vertex contained within said intersection path of said		
7	plurality vertices to a predetermined color when the intersection yields one region and when the		
8	intersection yields first and second disconnect regions, associating a second color with each		
9	vertex contained in said first disconnected region and a third color with each vertex contained in		
10	the second disconnected region, setting the color of vertices of a first portion of said single mesh		
11	contained within said intersection path to a first color and setting the color of vertices of a second		
12	portion of said single mesh contained within said intersection path to a second color when the		
13	intersection vields two unconnected regions, and		





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when said intersection path is an intersection between a first mesh and a second mesh, and said step of setting a polarity of each vertex of said plurality of vertices contained in said intersection path comprises setting the associating the second color of each of said plurality vertices of with each vertex of the first mesh contained within said intersection path and associating a third color with each vertex of the second mesh contained within said intersection path. to said first color and setting the color of each of said plurality vertices of the second mesh to said second color.

12. (Currently Amended) [[A]] The method of simulating motion of objects in computer animation according to claim 11 wherein said step of setting a simulated force between vertices of said at least one simulated object comprises:

setting said simulated force to cause an attraction between vertices of said at least one simulated object when said vertices are set to associated with said first or second or third colors:

setting said simulated force to cause [[an]] a repulsion between vertices of said at least one simulated object when said vertices are not set to associated with said first color, said second color, or predetermined said third color colors; and

setting said simulated force to cause neither an attraction or a repulsion between vertices of said at least one simulated object when said vertices are set to associated with said prodetermined first color.

13. (Currently Amended) A computer program product comprising: stored on a computer usable readable medium having computer readable program code means embodied in said medium for eausing a computer to manipulate and analyze for processing computer generated objects, said computer readable program eeds means product comprising:

means code for providing a plurality of objects represented by a plurality of meshes, with each of said plurality of objects being represented by one of said plurality of meshes and each of said meshes being formed by a set of vertices, where a set of pairs of vertices of said set of vertices define a set of edges;



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means code for checking all edges of said meshes to determine if said set of edges of said meshes intersect with any of said plurality of meshes;

means code for tracing an intersection path formed by intersection of said edges with any of said plurality of meshes; and

means code for determining which vertices of said meshes are contained within said intersection path; and and setting a polarity of each of said contained vertices to indicate that those vertices are contained within said intersection path.

code for setting a polarity of each vertex contained within said intersection path to indicate that said vertex is contained within said intersection path, wherein a polarity of a vertex is set based upon a number of disconnected regions formed by said intersection path.

- 1 14. (Currently Amended) [[A]] The computer program product according to of claim 13 wherein said means the code for determining which vertices of said meshes are contained within said intersection path comprises means code for examining vertices of a mesh that contains said intersection path within a certain distance from a particular edge of said intersection path and means for characterizing said vertices to determine which vertices of said meshes are contained within said intersection path.
  - 15. (Currently Amended) [[A]] The computer program product according to of claim 13 wherein said means the code for determining which vertices of said meshes are contained within said intersection path comprises:

means code for selecting an arbitrary edge of a mesh that crosses said intersection path, where said arbitrary edge is formed by vertices u and v and where said mesh contains said intersection path;

 $\frac{\text{means}}{\text{code}}$  for performing a search of said mesh, radiating from one of said vertices u and v, identifying all vertices in all of said edges that cross said intersection path, and defining the set of vertices identified as a playpen;

means code for tracing said intersection path and identifying vertices, within said playpen, on a left side of said intersection path as left and retracing said intersection path in an





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opposite direction and identifying vertices, with said playpen, on a right side of said intersection path as right;

means code for determining whether vertices adjacent to vertices identified as left and right lie outside of said playpen;

means code for discarding said intersection path when at least one of both left and right identified vertices lie outside said playpen;

means code for determining whether at least one vertex adjacent to said right identified vertices lies outside said playpen; and

means code for changing said polarity of characterizing each of said left identified vertices to indicate that those vertices are as contained within said intersection path when at least one vertex adjacent to said right identified vertices lies outside said playpen and changing said polarity of characterizing each of said right identified vertices to indicate that those vertices are as contained within said intersection path when at least one vertex adjacent to said left identified vertices lies outside said playpen.

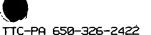
16. (Currently Amended) [[A]] The computer program product according to of claim 13 wherein said intersection path is a self-intersection with the intersection path being contained in a single mesh and said means the code for setting a polarity of each vertex of said contained vertices to indicate that those vertices are contained within said intersection path comprises; means for setting the

code for associating a first color of said vertices that are with each vertex that is contained within said intersection path to a predetermined color when the intersection yields one region; and

when the intersection yields first and second disconnected regions, means code for setting the associating a second color with each vertex contained in said first disconnected region and associating a third color with each vertex contained in the second disconnected region, of vertices of a first portion of said single mesh contained within said intersection path to

13 a first color and setting the color of vertices of a second portion of said single mesh contained





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within said intersection path to a second color when the intersection yields two unconnected regions.



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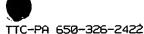
17. (Currently Amended) [[A]] The computer program product according to of claim 13 wherein said intersection path is an intersection between a first mesh and a second mesh and said means of the code for setting a polarity of each vertex of said contained vertices to indicate that those vertices are contained within said intersection path comprises means code for setting the associating a first color [[of]] with vertices of the first mesh contained within said intersection path to a first color and code for associating a second setting the color [[of]] with vertices of the second mesh contained within said intersection path to a second color.

18. (Currently Amended) [[A]] The computer program product according to of claim 16-one of claims 16-and 17, further comprising means code for displaying said objects on a computer display with vertices eclored as said vertices have been set displayed in colors associated with the vertices.

19. (Currently Amended) A computer program product comprising: stored on a computer usable readable medium having computer readable program code means embodied in eaid medium for eausing a computer to manipulate and analyze processing computer generated objects in computer animation, said computer readable program product code means comprising: means code for providing a plurality of objects represented by a plurality of meshes, with each of said plurality of objects being represented by one of said plurality of meshes and each of said meshes being formed by a set of vertices; means code for determining an intersection path formed by analyzing intersections between said objects and means for changing a polarity of each of a plurality vertices contained in an intersection path created by an intersection of said plurality of meshes; code for setting a polarity of each vertex contained within said intersection path



based upon a number of disconnected regions formed by said intersection path:



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surfaces of said objects and closer to one of said surfaces, where said surfaces have defined insides and outsides and said particular vertex is inside of both surfaces;

means code for determining whether any vertices inside of said surfaces have their polarities set; and

their polarities set; and
 means code for indicating that said particular vertex is pinched when any vertices

inside of said surfaces have their polarities set.

means code for selecting a particular vertex of said set of vertices bound between

20. (Currently Amended) [[A]] The computer program product according to of claim 19 further comprising:

means code for constraining motion of said pinched particular vertex when

means code for constraining motion of said pinched particular vertex when motion in said computer animation is simulated.

21. (Currently Amended) [[A]] The computer program product according to of claim 19 wherein said means for changing the code for setting a polarity of each vertex of a plurality vertices contained in an said intersection path comprises means code for setting the associating a color of each of a plurality vertices with each vertex contained in an said intersection path, the computer program product and further comprising[[:]] means code for displaying said objects on a computer display with vertices displayed in colors associated with the vertices colored as said vertices have been set such that an animator can see the intersection and pinching of said objects is visually displayed.

22. (Currently Amended) A computer program product comprising: stored on a computer readable usable medium having computer readable program code means embodied in said-medium for causing a computer to manipulate and analyze for processing computer generated objects in computer animation, said computer readable program product code means comprising:

means code for providing a plurality of objects represented by a plurality of meshes, with each of said plurality of objects being represented by one of said plurality of



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meshes and each of said meshes being formed by a set of vertices, where at least one of said
objects is an animated object and at least one of said objects is a simulated object;

means code for positioning said objects at some time t to provide one frame of said computer animation;

means code for determining an intersection path formed by analyzing intersections between said objects and setting a polarity of each of a plurality vertices contained in an intersection path created by an intersection of said plurality of meshes;

based upon a number of disconnected regions formed by said intersection path:

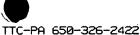
means code for setting a simulated force between vertices of said at least one simulated object based on the polarity set for said vertices of said at least one simulated object; and

means code for advancing the computer animation to a time  $t + \Delta t$  and simulating motions of said objects using said simulated force to simulate motions of said at least one simulated object.

23. (Currently Amended) [[A]] <u>The</u> computer program product according to of claim 22 wherein

when said intersection path is a self-intersection with the intersection path contained in a single mesh, said means code for setting a polarity of each vertex contained within said polarity of each of said plurality vertices contained in said intersection path comprises means code for associating a first color with each vertex contained within said intersection path setting the color of each of said plurality vertices to a predetermined color when the intersection yields one region and when said intersection path yields first and second disconnected regions, code for associating a second color with each vertex contained in said first disconnected region and a third color with each vertex contained in the second disconnected region, setting the color of vertices of a first portion of said single mesh contained within said intersection path to a first color and setting the color of vertices of a second portion of said single mesh contained within





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when said intersection path is formed from an intersection between a first mesh and a second mesh, the code for said means for setting a polarity of each vertex of said plurality of vertices contained in said intersection path comprises means code for setting the associating the second color of each of said plurality vertices with each vertex of the first mesh to said first color and setting the associating the third color with of each of said plurality vertices vertex of the second mesh to said second color.

eaid intersection path to a second-color when the intersection yields two unconnected regions,

24. (Currently Amended) [[A]] The computer program product according to of claim 23 wherein said means for the code for setting a simulated force between vertices of said at least one simulated object comprises:

means code for setting said simulated force to cause an attraction between vertices of said at least one simulated object when said vertices are set to associated with said first or second or third colors;

means code for setting said simulated force to cause [[an]] a repulsion between vertices of said at least one simulated object when said vertices are not set to associated with said first color, said second color, or predetermined said third color colors; and

means code for setting said simulated force to cause neither an attraction or a repulsion between vertices of said at least one simulated object when said vertices are set to associated with said predetermined first color.

- (New) The method of claim 5, further comprising displaying said objects 25. on a computer display with vertices displayed in colors associated with the vertices.
- 26. (New) The computer program product of claim 17, further comprising 1 code for displaying said objects on a computer display with vertices displayed in colors 2 associated with the vertices. 3
  - 27. (New) A method of analyzing intersections, the method comprising:





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determining an intersection path formed by an intersection of a first mesh portion and a second mesh portion, wherein each mesh portion comprises a plurality of vertices;

determining a set of vertices of the first mesh portion and the second mesh portion that are contained within the intersection path; and

setting a value for each vertex in the set of vertices based upon based upon a number of disconnected regions formed by said intersection path.

- 28. (New) The method of claim 27 wherein the first mesh portion and the second mesh portion are portions of a mesh representing an object.
- 1 29. (New) The method of claim 27 wherein the first mesh portion is a portion of a first mesh representing a first object and the second mesh portion is a portion of a second mesh representing a second object.
  - 30. (New) The method of claim 27 wherein setting a value for each vertex in the set of vertices comprises:

setting each vertex in the set of vertices to a first value if a single region is formed by the intersection path; and

if the intersection path forms a first region on the first mesh portion and a second region on the second mesh portion that is disconnected from the first region,

setting each vertex in the set of vertices that is in the first region to a second value, and

setting each vertex in the set of vertices that is in the second region to a third value.

